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1. INTRODUCTION

The Air Emissions Licenses (AEL) for Eskom power stations in the Nkangala District Municipality (Hendrina, Arnot, Komati, Kriel, Matla, Kendal and Duvha), Gert Sibande District Municipality (Majuba, Tutuka, Camden and Grootvlei) and Fezile Dabi (Lethabo) requires that each of the Eskom power stations implement an Emissions Offset Programme to reduce Particulate Matter (PM) in the ambient environment. The AELs' requirements is similar to a condition in the National Air Quality Officer's decision (February 2015) on Eskom's power stations' application for postponement of the compliance timeframes with the National Environmental Management: Air Quality Act (Act No 39 of 2004) section 21 Minimum Emission Standards, which states that each power station is '*to implement an offset programme to reduce PM in the ambient/receiving environment. A definite offset implementation plan is expected from Eskom by 31 March 2016.*'

Air quality offsets address emission sources within vulnerable communities in the vicinity of Eskom's coal-fired power stations in the relevant district municipalities, targeting greater improvement in the community air quality than is achievable from other approaches. The Air Quality Offset Implementation Plans covers the period from April 2016 to March 2025.

Eskom's Air Quality Offset Implementation Plans for Nkangala District Municipality, Gert Sibande District Municipality and Lethabo Power Station were submitted to the National Air Quality Officer and the relevant Atmospheric Emission Licensing Authorities on the 28 April 2016 (ENV16_R016, ENV16_R017 and ENV16_R018). Updated plans were submitted to Authorities in April 2021 (ENV21_R051, ENV21_R052 and ENV21_R053). The plans detail the proposed offset interventions per selected settlement. It also details the approach followed in selecting settlements; selecting, designing and implementing interventions; and assessing the effectiveness of the interventions. The plans were approved by the National Air Quality Officer in concurrence with the relevant Atmospheric Emission Licencing Authorities on the 16 September 2016.

As a condition of the approval, Eskom is required to "*implement the air quality offsets according to the approved plans*" and to submit an annual progress report to the "*National Air Quality Officer and the relevant Atmospheric Emission Licensing Authorities for the duration of the implementation*".

The purpose of this report is to provide feedback on progress made in the implementation of the Air Quality Offset Plans in the applicable district municipality during the period: 01 April 2020 to 31 March 2021.

2. AIR QUALITY OFFSET INTERVENTIONS: NKANGALA AND GERT SIBANDE

The key contributor to poor air pollution in Highveld is domestic coal burning. Based the results of the pilot studies conducted in 2016 – 2018, it was concluded that ambient air quality in the affected communities in the Highveld (Nkangala and Gert Sibande) could be improved by replacing household's coal stoves with hybrid gas-electricity stoves and an LPG heater together with retrofitting the houses with a ceiling to insulate the houses. The Air Quality Offset intervention for Nkangala and Gert Sibande District Municipality will thus entail the following (Figure 1):

- Provision of a basic plus retrofit which consists of;
    - Insulation entailing installation of an SPF ceiling system and draft proofing
    - Electrical rewiring and issuance of Certificate of Competence (CoC).
- Stove swap, which entails
    - Provision of electricity based energy source with LPG backup. This will include a hybrid gas-electric stove, LPG heater plus 2x9 kg LPG cylinders and Compact fluorescent lamp (CFL) for energy efficient lighting.
    - Removal and disposal of the coal stove

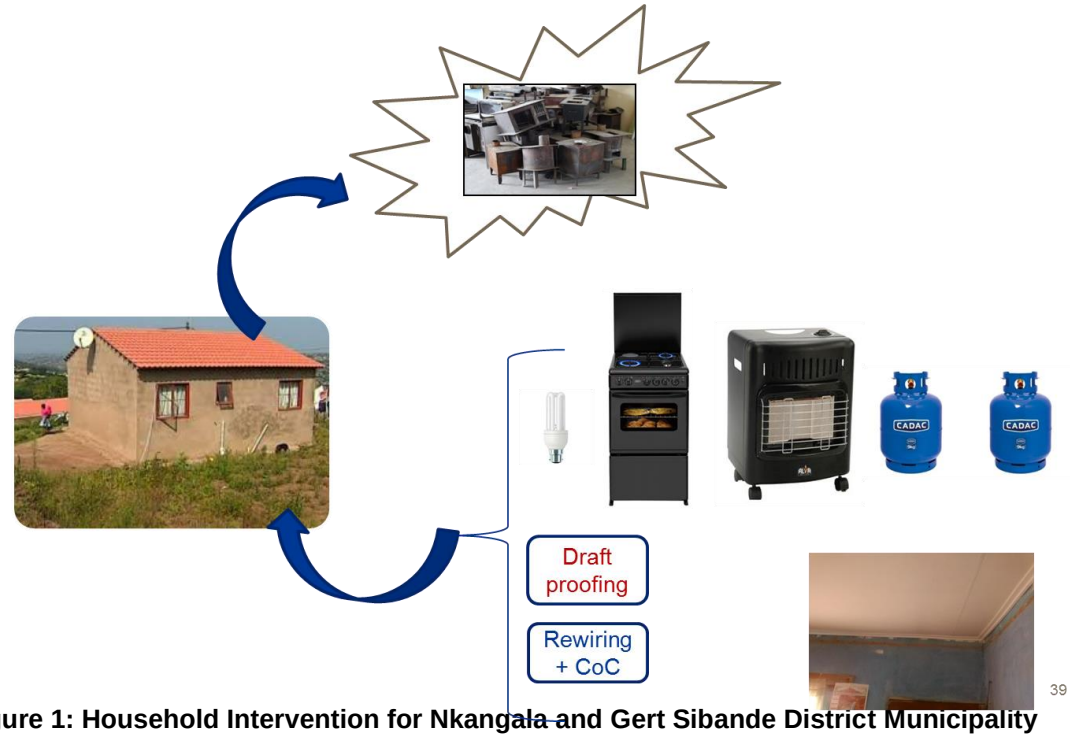

Figure 1: Household Intervention for Nkangala and Gert Sibande District Municipality

3. AIR QUALITY OFFSET INTERVENTIONS: FEZILE DABI

In the Vaal, waste burning was identified as a key contributor to poor ambient air quality. Based on results of the baseline assessment done in 2018, it was decided to rollout air quality offset interventions in selected settlements in Fezile Dabi and Sedibeng district municipality that entails the following;

- Clean up of waste and provision of waste collection services for a period of six months
- Establishment of parks and greening of selected areas

These interventions will be pilot tested in Sharpeville as part of phase 1 with the aim of rolling out similar interventions in Tshepiso, Boipatong (in phase 2) and Refengkotso (in phase 3).

4. PHASED APPROACH

Air quality offsets is an emerging field, and interventions of the type and scale contemplated in this document have not been implemented before. Accordingly, a phased approach is adopted to increase the probability of success and to ensure that learnings from early phases are incorporated into the large scale rollout. The phased approach entails the following:

- *Phase 0: Pilot project*. An intervention is tested on a small scale to discover practically what works.
- *Phase 1:* The intervention is tested on an entire community to see how best to scale up an initiative. The lead implementation is designed to benefit the specific local community, minimize implementation risk, increase practical and scientific knowledge, and develop and refine monitoring, reporting and verification processes.
- *Phase 2: Full implementation* (balance of qualifying households in bigger settlements). Once the intervention has been refined, and the learnings of the lead implementation incorporated, the intervention will be rolled out simultaneously at several large communities across the three district municipalities and selected areas in the Vaal.
- Phase 3 *Full implementation* (balance of qualifying households in smaller settlements). Once the intervention has been refined, and the learnings of the lead implementation incorporated, the intervention will be rolled out simultaneously at several small semi-rural communities, the three district municipalities and selected areas in the Vaal.

A typical offset implementation (lead or full) in a community will have three stages: baseline establishment; implementation; and monitoring and verification (see figure 2 below).

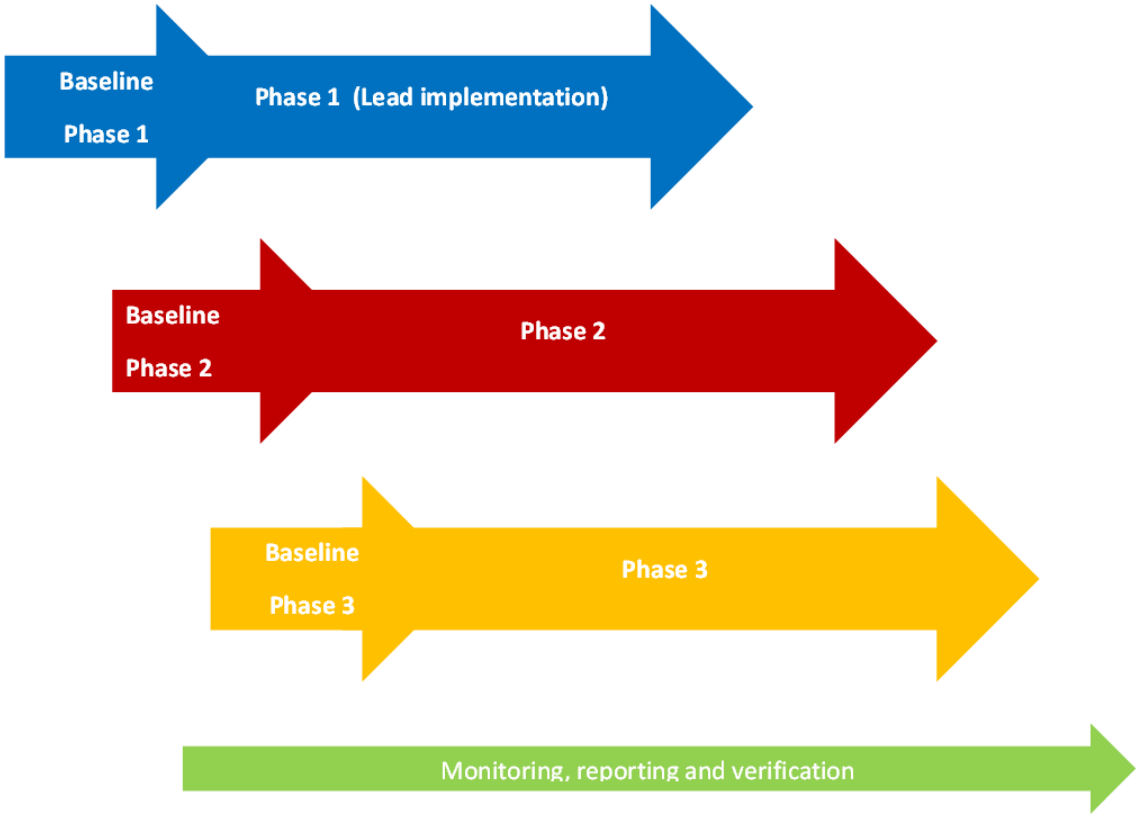

Figure 2: Concept schedule for the implementation of air quality offsets

4.1 PROGRESS FROM APRIL 2020 TO MARCH 2021

The rollout of interventions for Phase 1 in KwaZamokuhle, Ezamokhule and Sharpeville (lead implementation) according to the March 2020 plan was initially scheduled to commence in April 2020. There has been a number of delays of about 12 months due to, amongst other things; the COVID-19 pandemic and national lockdown and procurement delays (some internal and some external due to poor submissions from service providers). Phase 1 implementation (rollout of interventions) commenced in February 2021 in KwaZamokuhle with mobilazation of the PMV, PMO and insulation contracts and the registration of qualifying households. Interventions in Ezamokuhle and Sharpeville are planned to commence in May 2021.

The following were achieved from April 2020 to March 2021:

- Contracts from the following work packages have been signed;
    - Planning, Monitoring and Verification for phase 1
    - Health study in KwaZamokuhle and Ezimononi

  - Project Management Office for KwaZamokuhle
  - Insulation for KwaZamokuhle
- Procurement for the following work packages are underway
  - Project Management Office for Ezamokuhle
  - Insulation for Ezamokuhle
  - Heaters and stoves for KwaZamokuhle and Ezamokuhle
  - Clean-up in Sharpeville
  - Parks establishment in Sharpeville
- Eskom has established and maintained baseline air quality monitoring sites in the following areas;
  - KwaZamokuhle
  - Ezamokuhle
  - Phola
  - Thubelihle
  - Silobela
  - Emzimnoni
  - Masakhane
  - Silobela
  - Sivukile.
- Last year, Eskom obtained a high-level agreement on Sharpeville interventions with Sedibeng District and Emfuleni Municipality. A Memorandum of Agreement is being finalized to formalize the agreement.
- Eskom had a number of stakeholder meetings/engagements with affected communities and municipalities (refer to section 7).

4.2 PROGRESS SINCE INCEPTION OF AIR QUALITY OFFSET PROGRAMME

Table 1 provides a summary of progress made in implementing Eskom Air Quality Offset Plans in Nkangala District Municipality, Gert Sibande District Municipality and Fezile Dabi District Municipality since the inception of the Air Quality Offset programme. Details are outlined in section 3 to 5.

Table 1: Summary of progress made in implementing Air Quality Offset Plans

Phase	Activities	Nkangala	Gert Sibande	Fezile Dabi
0	Pre-feasibility study	√	√	N/A
	Pilot project	√	√	N/A
1	High-level plan	√	√	√

	Authority approvals	√	√	√
	Budget approvals	√	√	√
	Baseline monitoring for lead	√	√	√
	Implementation of phase 1 (lead)	×	×	×
	Monitoring and verification	×	×	×
2	High-level plan	√	√	√
	Authority approvals	√	√	√
	Budget approvals	×	×	×
	Baseline monitoring for phase 2	√	√	×
	Implementation of phase 2	×	×	×
	Monitoring and verification	×	×	×
3	High-level plan	√	√	√
	Authority approvals	√	√	√
	Budget approvals	×	×	×
	Baseline monitoring for phase 3	×	×	×
	Implementation of phase 3	×	×	×
	Monitoring and verification	×	×	×

5. IMPLEMENTATION OF AIR QUALITY OFFSETS PLANS

Eskom has completed pre-feasibility and pilot studies (phase 0) and have developed a high-level plan and obtained the approval of the plans from the authorities (Department of Environment, Forestry and Fisheries). The budget for phase 1 (which includes KwaZamokule, Ezamokuhle and Sharpeville) has been approved by IFC on 06 February 2020. The project team are currently finalizing procuring services required to implement phase 1 part of the programme (refer to section 4.1 for status). Budget approval for phase 2 and 3 is still pending.

5.1 NKANGALA DISTRICT MUNICIPALITY

The rollout of interventions in KwaZamokuhle was initially planned to start in April 2020. This has been delayed for a period of 14 months due to, amongst other things; COVID-19 pandemic and national lockdowns and procurement delays (due to a failure timeously procure and contract with service providers). Implementation (rollout of interventions) in KwaZamokuhle commenced in February 2021 in KwaZamokuhle with mobilization of the PMV, PMO and insulation contracts and the registration of qualifying households. An updated Air Quality Offsets Implementation Plan for power stations in the

Nkangala District Municipality will be submitted to DEFF before 31 March 2021. A high-level program is depicted below:

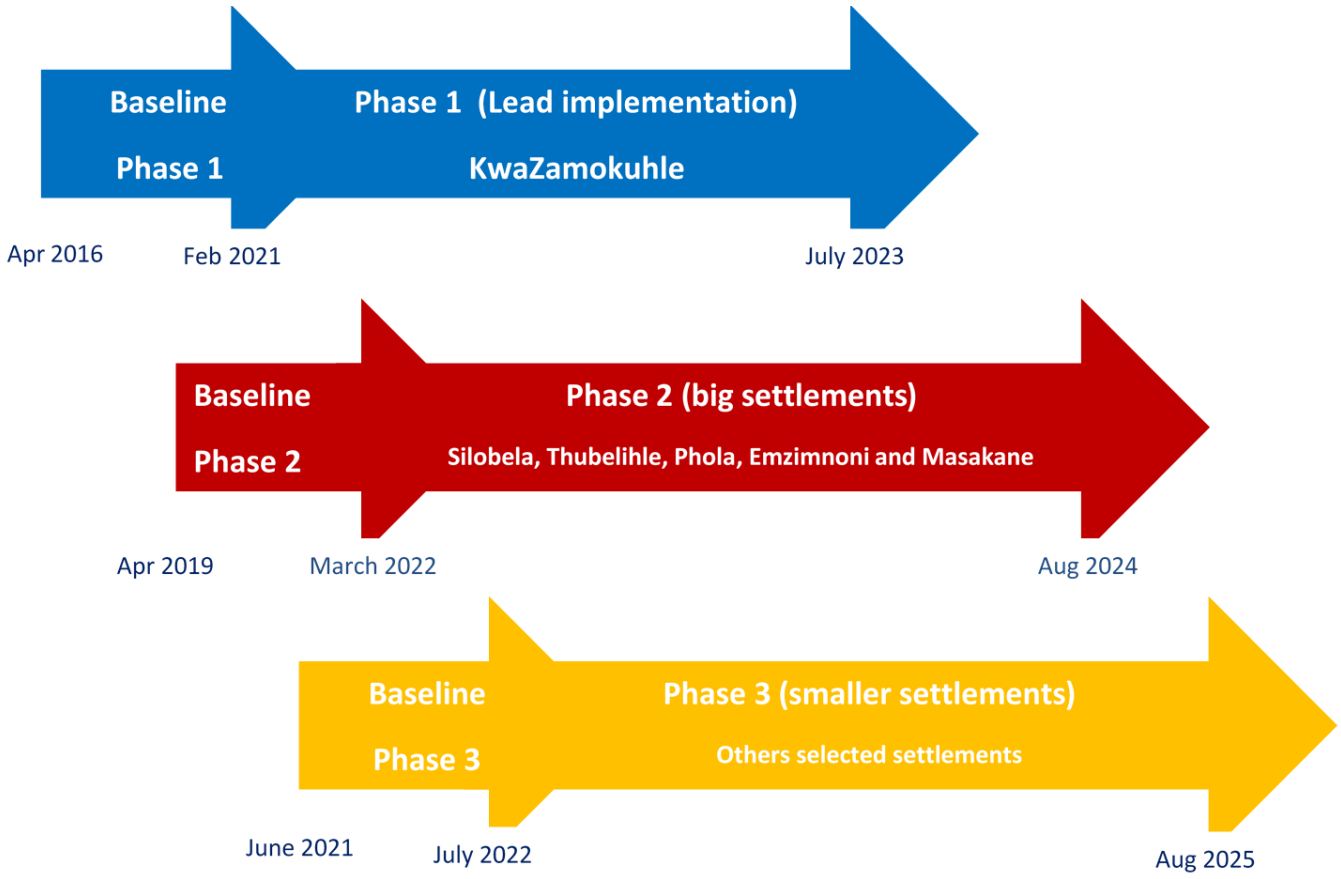

Figure 3: Concept schedule for the implementation of air quality offsets in the Nkangala District Municipality

5.2 GERT SIBANDE DISTRICT MUNICIPALITY

The rollout of interventions in Ezamokuhle was initially planned to start in April 2020. This has been delayed for a period of 14 months due to, amongst other things; COVID-19 pandemic and national lockdowns and procurement delays (and due to the failure timeously procure and contract with service providers). Implementation of intervention is now scheduled to commence in May 2021 with registration of qualifying households. An updated Air Quality Offsets Implementation Plan for power stations in the Gert Sibande District Municipality will be submitted to DEFF in 31 March 2021. A high-level program is depicted below:

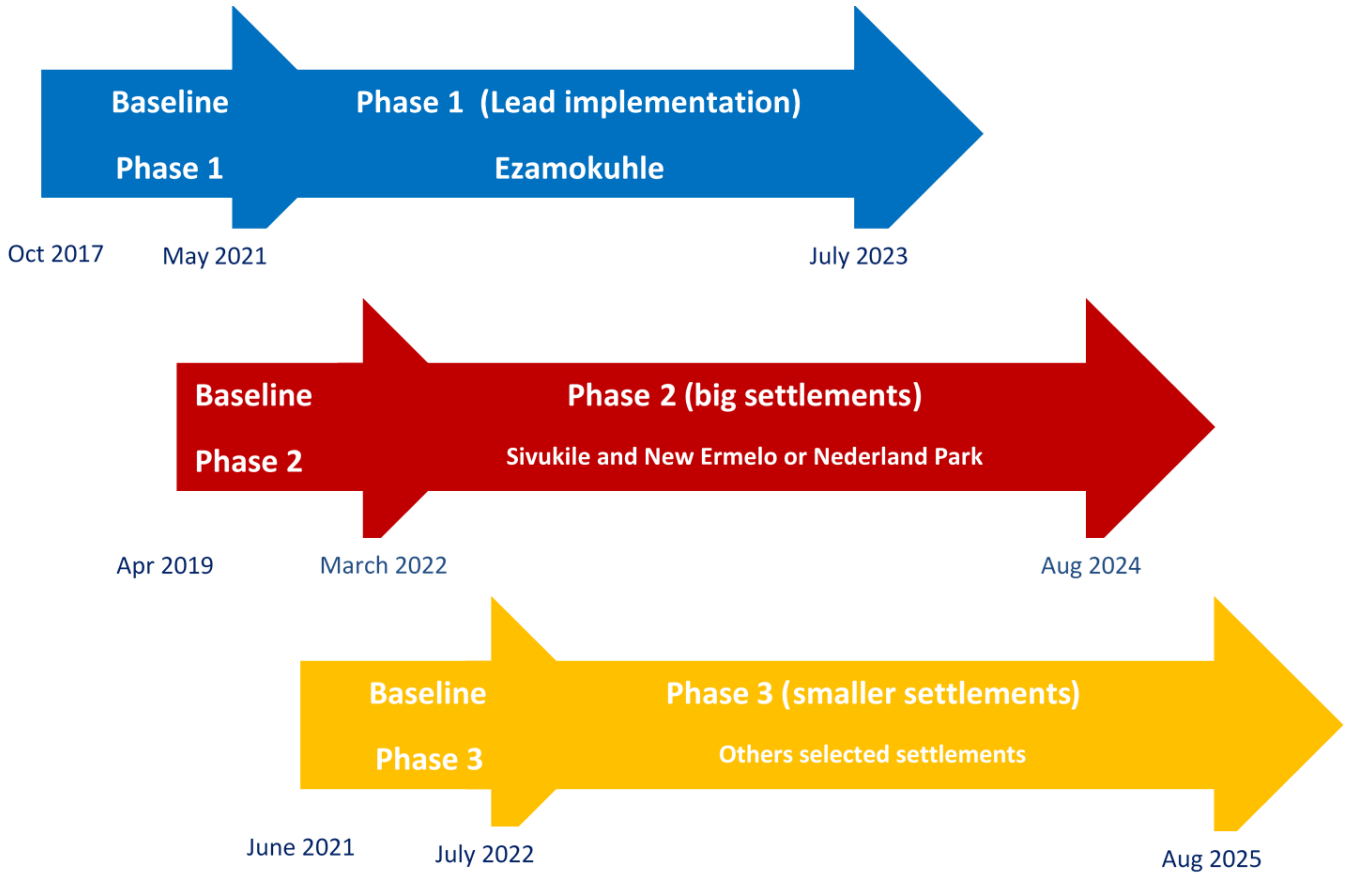

Figure 4: Concept schedule for the implementation of air quality offsets in the Gert Sibande District Municipality

5.3 FEZILE DABI DISTRICT MUNICIPALITY

The rollout of interventions in Sharpeville was initially planned to start in April 2020. This has been delayed for a period of 13 months due to, amongst other things; COVID-19 pandemic and national lockdowns and procurement delays (due to a failure to timeously procure and contract with service providers). Implementation of intervention is now scheduled to commence in May 2021. An updated Air Quality Offsets Implementation Plan for power stations in the Fezile Dabi District Municipality will be submitted to DEFF in 31 March 2021. A high-level program is depicted below:

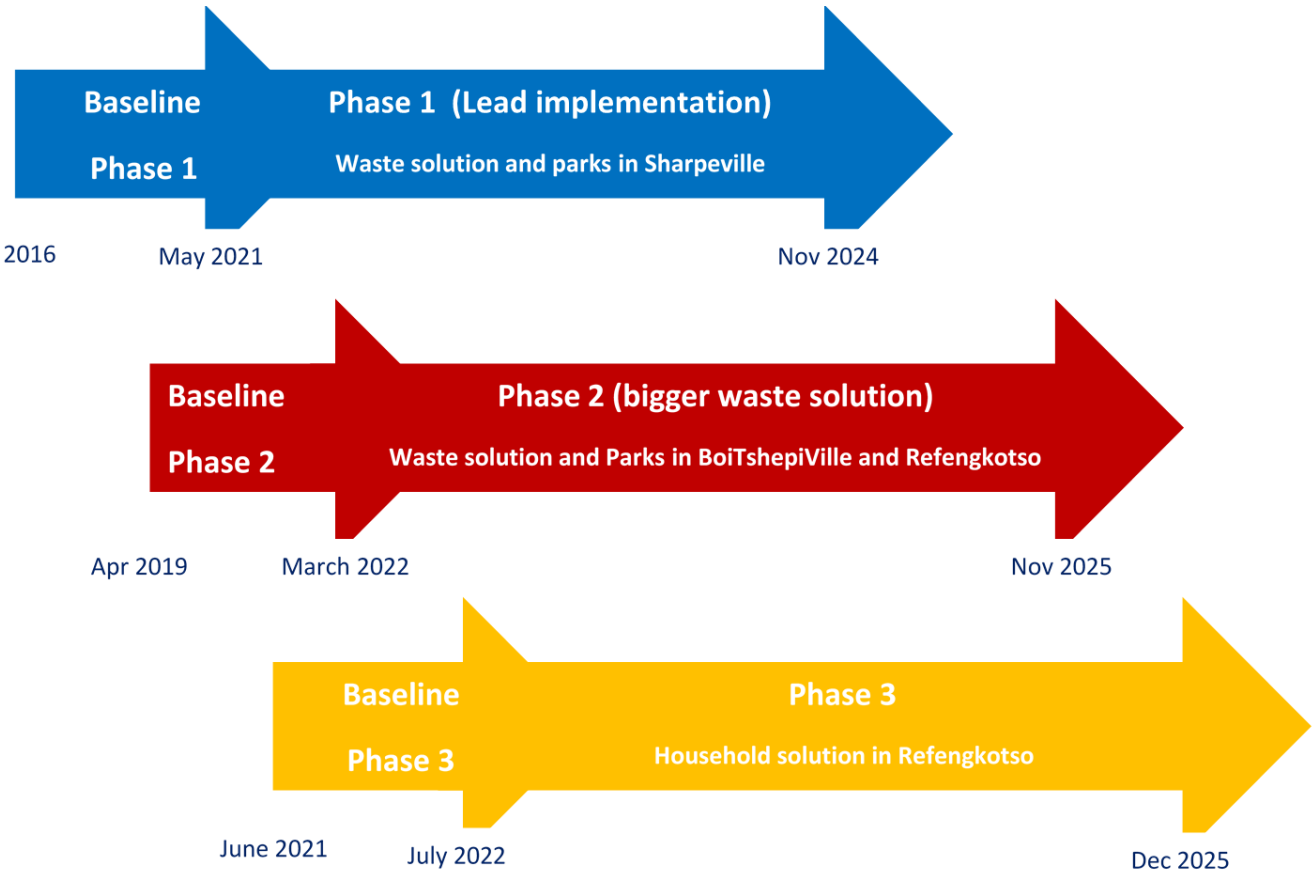

Figure 5: Concept schedule for the implementation of air quality offsets in the Fezile Dabi District Municipality

5.4 BASELINE MONITORING

The Planning, Monitoring and Verification (PMV) contract has been established. The object of the PMV contractor is to assist with detailed planning for the interventions and continuous monitoring and reporting of the project progress and effectiveness. Progress has been made with the following activities in Ezamokuhle.

- Preliminary air quality assessment
- Gathering of area intelligence
- Rapid in-situ assessment
- Ethical clearance

Work on the census, community source survey, fuel source survey and household surveys is planned to start in the next two months.

Figure 6: Ezamokuhle aerial pics taken using drones during the rapid in-situ activity.

Baseline air quality monitoring has been established in KwaZamokuhle since April 2016 as part of the pilot phase (phase 0). Monitoring in Ezamokuhle was established in 2017. Monitoring for phase 2 at Silobela, Thubelihle, Masakane, Phola, Emzinoni and Sivukile was in place by April 2019 and was fully functional by September 2019. A decision is yet to be taken on the implementation of baseline monitoring for New Ermelo, Fezile Dabi phase 2 settlements and phase 3 in all affected districts.

Table 3: Baseline monitoring status for phase 1 and 2 settlements

Phase	Power station	Settlement	Baseline monitoring
1	Hendrina	KwaZamokuhle	√
	Majuba	Ezamokuhle	√
2	Arnot	Silobela	√
	Kriel	Thubelihle	√
	Matla	Emzinoni	√
	Kendal	Phola	√
	Duvha	Masakane	√
	Camden	New Ermelo	×

5.5 HEALTH ASSESSMENT STUDY

The South African Medical Research Council (SAMRC) was appointed by Eskom Holdings SOC Limited to undertake a health assessment to evaluate the health impacts of household-level interventions to curb air pollution caused by domestic burning practices during the winter period. This, in collaboration with the Eskom's air quality offset intervention project.

A non-randomized controlled trial study was designed to take place in two of the communities selected for air quality interventions, namely KwaZamokuhle and Emzinoni, respectively. The SAMRC, along with the University of KwaZulu-Natal (UKZN) and The Nova Institute (Nova) are working in collaboration to conduct a multi-year study in a phased approach, as follows:

Phase 1: Baseline / Pre-intervention study and;

Phase 2: Post-intervention study

The Eskom's air quality offset intervention project will be implemented after phase 1 of the health assessment in KwaZamokuhle only, with Emzinoni being a control site. The initial report of **Phase 1** of the study has been completed and presents interim results for baseline data collected and analyzed in both communities between 1 July 2019 and 31 January 2020. Interim results show that ambient air pollution levels in both study area's are high and, at times, surpass levels deemed as "safe to breathe" in terms of the National Ambient Air Quality Standards (NAAQS). The report will be shared with key role players in due course.

The majority of phase 1 of the health study has been completed, and the interim report has been submitted to Eskom. Phase 2 of the health study has been negatively impacted as a result of confounding factors resulting from the COVID-19 pandemic and the National lockdown situation. This relates mainly to the health data. After deliberation between Eskom and MRC (informed by consultation with multiple epidemiologists), **a decision was taken to stop the project**. Processes are underway to wrap up outstanding matter and terminate the contract.

6. IMPACT ASSESSMENT

Section 4.4 (g) of Atmospheric Emission Licenses (AELs) requires that each "facility must implements offset programs as approved and submit to the Licensing Authority annually the impact report demonstrating reduction of PM and SO_2 pollution in the ambient air/receiving environment as of the financial end 2019/2020".

This section of the report was meant to provide results of the impact assessment of the air quality offsets initiatives. Unfortunately, because no interventions have been implemented to date, there is nothing to report at this stage.

7. STAKEHOLDER ENGAGEMENT

Eskom has been actively engaging its stakeholders on air quality offsets implementation plans, including the affected municipalities. During this financial year (April 2020 to March 2021), Eskom held a number of stakeholder meetings and engagements with affected communities and municipalities, including the following;

- Sharpeville Project Feedback (Meeting with Councillors and eMfuleni Local Municipality) - 17 September 2020
- Meeting with Steve Tshwete Local Municipality - 6 October 2020
- Meeting with Kwazamokuhle Councillors - 22 October 2020
- Kwazamokuhle community meeting - 4 November 2020
- Engagement with the Speaker from Pixley Ka Seme Local Municipality - 25 January 2021
- Engagement with the Speaker from Pixley Ka Seme Local Municipality and Ezamokuhle Councillors - 27 January 2021
- Meeting with Councillors and eMfuleni Local Municipality - 2 February 2021
- Regulate project updates to Sedibeng, Sasolburg, Nkangala and Gert Sibande ITT's.

The first round of registration of qualifying households In KwaZamokuhle was conducted in from the 13 February 2021 to 19 February 2021. More registrations in KwaZamokuhle are planned for the coming weeks. Registration in Ezamokuhle is planned to commence in May 2021.

Some concerns have been raised in the engagements that have been held. For example, concerns have been raised with intevension undertaken during the pilot phase of the project. The project team is responsing to these issues.

8. CHALLENGES ENCOUNTERED

Eskom has experienced delays of in excess of 12 months in the implementation of the Air Quality Offset Plans for power stations around Nkangala, Gert Sibande and Fezile Dabi District Municipalities. The delay is mainly due to COVID-19 and national lockdowns and procurement delays (the failure to timeously procure and contract with service providers). Due to these delays, the implementation plans had to be revised and updated.

This schedule depends on the budget being made available. Should there be a cut in the allocation of funding to this project, it will translate directly into a delay in this schedule. This schedule also depends on approval from the relevant authorities. Should approval be delayed, or should significant changes be required to this plan, the rollout of offsets will be delayed. The authorities will be notified of any such developments.

9. PROGRAMME RISKS

Risks and unintended consequences of an air quality offsets programme and the way in which Eskom proposes to mitigate the risks as follows:

Table 4: Risks of air quality offsets and proposed mitigation

Risk	Risk rating	Mitigation already in place	Planned mitigation
Money used by households to buy electricity will be used instead to pay off municipal debts.	High		Engagements will be held with the local municipalities to see if an agreement can be reached regarding the payment of household debts.
Funding constraints: Funds have been allocated for offsets implementation, but they may be cut	Medium	Funding requirements were included in MYPD tariff application, but with tariff reduction, this provides limited mitigation now	Compliance aspects of offsets will be presented during capital reprioritization and with specific offset funding requests.
Objections from communities that are not included in the implementation of the offset	Medium	An objective process has been used to select communities. Also, offsets will not be implemented in a section of a community only. In-depth community consultation will only occur after authority approval of the plan and allocation of budget.	Most communities in the vicinity of power stations will eventually receive an offset implementation
Unreliable supply of electricity will leave communities without an energy source at times.	Medium		The proposed intervention include the provision of an LPG backup.
Safety: Electric wiring in many houses is unsafe. Injuries may be caused by electric heaters or stoves.	Medium	-	The project team will ensure the wiring is safe after the installation of the gas-electric stove and ceiling. An electrical CoC will be issued by a competent electrician. Members of the local community will be trained in safe operations prior to the installations. The Health and safety requirements of Eskom's procurement process will be adhered to.
Objections from households that do not use solid fuels	Low	-	An understanding of the objectives of the offsets rollout and the secondary benefits for non-participating households will need to be conveyed through community consultation and awareness initiatives.

Risk	Risk rating	Mitigation already in place	Planned mitigation
The inability of local authority to support/facilitate waste and household solutions impacting on the ability to create sustainable solutions	High	Continued engagement with authorities	Continued engagement with authorities Consider projects which require less authority involvement
COVID 19 impacts affecting potential community interaction and commercial processes	High	COVID-19 protocol in place	COVID-19 protocol in place
Negative perception from previous pilot	Medium		Priorities households that participated in the pilot.

10. CONCLUSION

Despite the challenges encountered, Eskom has made some progress in the implementation of the air quality plans in the Nkangala, Gert Sibande and Fezile Dabi District Municipalities. These include;

- Registration of qualifying household has commenced in KwaZamokuhle. All the required contracts to provide the required services are being finalised.
- Procurement of the remaining services required for rollout of interventions in Ezamokuhle are at an advance stage.
- Held successful meetings with municipalities and communities.
- Despite security concerns at some of the air quality monitoring site, most are up and running.
- PMV contract in place, and delivering good outputs.
- Health study by MRC delivered good outputs but unfortunately had to be terminated due to confounding facts as a result of COVID-19.

Updated Air Quality Offsets Implementation Plans will be submitted to DEFF before 31 March 2021 reflecting the new proposed rollout schedule and changes in the project plan.

11. REFERENCES

Eskom, 2021: *Air Quality Offsets Implementation Plan for Nkangala District Municipality*, March 2021 update.

Eskom, 2021: *Air Quality Offsets Implementation Plan for Gert Sibande District Municipality*, March 2021 update.

Eskom, 2021: *Air Quality Offsets Implementation Plan for Lethabo Power Station*, March 2021 update.

12. APPENDIX A: PREFEASIBILITY STUDY

Eskom's exploration of air quality offsets started with a pre-feasibility study conducted by EScience Associates and the Nova Institute in 2013. The objective of this study was to determine the most feasible interventions to offset tall stack emissions from Eskom's power stations by reducing household emissions. Household interventions were selected based on the numerous scientific studies that show that in South Africa the main cause of harmful health effects due to poor air quality is the domestic burning of solid fuels.

An exhaustive list of household interventions was brainstormed, and kick-out criteria were then applied to reduce the list for detailed evaluation. The shortened list of interventions was then evaluated according to the following weighted criteria:

- Reduced human exposure to ambient PM10
- Reduced human exposure to ambient SO_2
- Implementation cost attractiveness of intervention
- Success probability of intervention
- Government and Eskom Board acceptance of intervention
- Sustainability of intervention
- Household acceptance of intervention
- Indirect impact of implementation (long and short term)

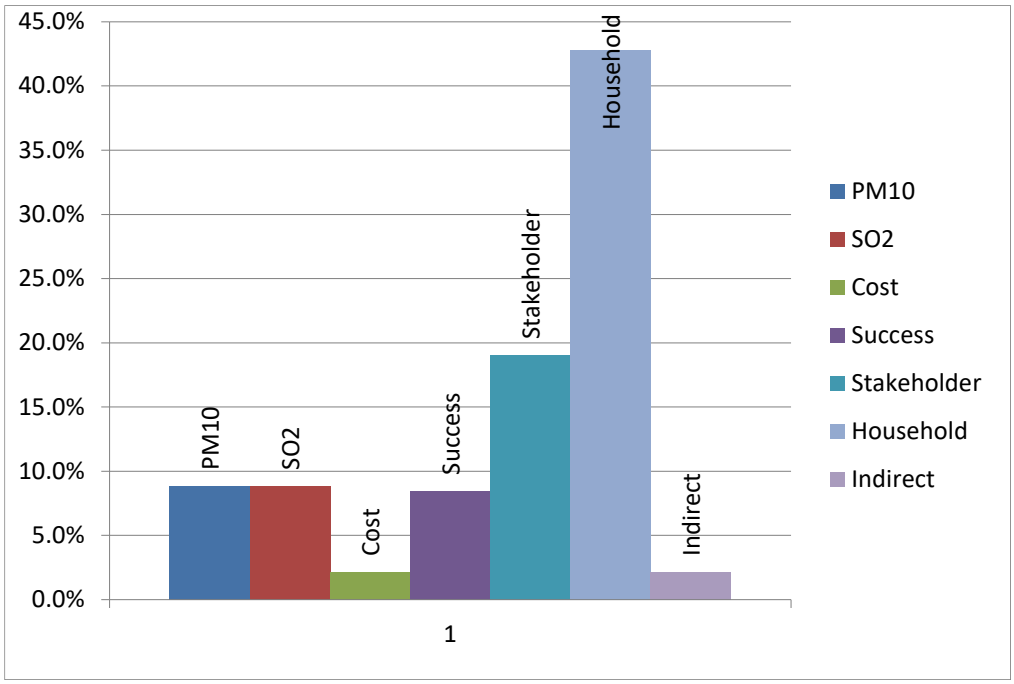

Figure A1: Weighting of the criteria used to evaluate the proposed offset interventions

Households are considered to be the most important stakeholder, and their acceptance was identified as the most important criterion that would determine the success of the offset projects, followed by acceptance by licencing authorities and the Eskom Board.

The interventions recommended for further study, based on applying the weighted criteria were:

- Retrofit full suite of thermal shell insulation (ceilings and three walls), draft proofing and Trombe wall on all existing subsidy houses [Full retrofit]
- Install ceilings in all formal houses [Ceilings]
- Optimize house size, shell insulation, ventilation, orientation and solar heat absorption for new subsidy houses and social housing [EE RDP]
- Replace coal / wood stove with multi-purpose, high quality, low emission stove [New stove]
- Electricity subsidy
- Gas subsidy with equipment [LPG subsidy & heater]

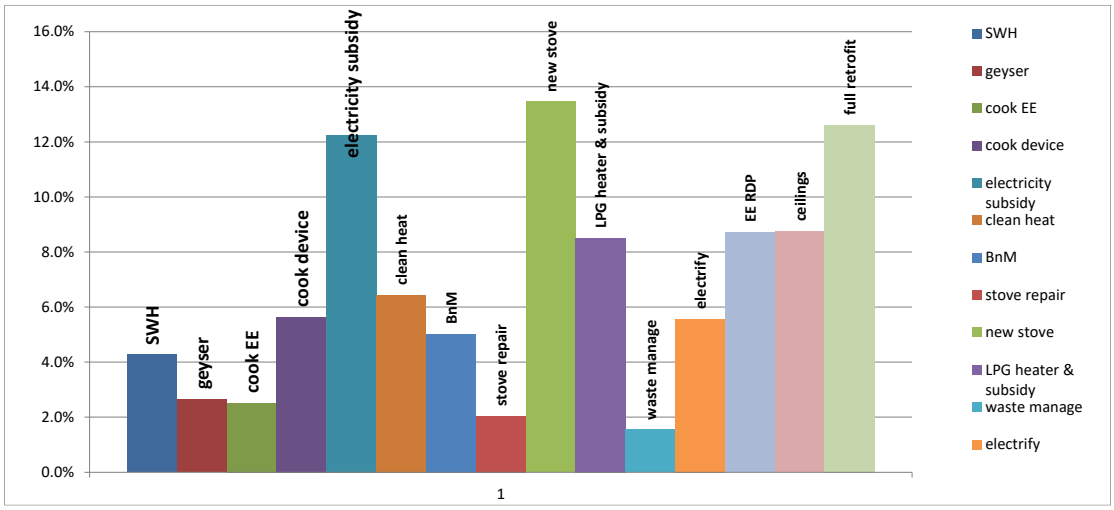

Figure A2: Result of applying the evaluation criteria. (Relative weighing on y-axis)

12.1 AIR QUALITY OFFSETS: 120-HOUSE PILOT STUDY

Following on from the pre-feasibility study, the next step in Eskom's air quality offsets journey was an air quality offsets pilot project, which was conducted in KwaZamokuhle (3 km from Hendrina town, Mpumalanga) from mid-2014 to end 2015. The project team was comprised of experts from the North-West University, the Nova Institute, the Council for Scientific and Industrial Research, EScience Associates and Prime Africa Consulting.

The objective of the pilot study was to evaluate the household-based air pollution offset interventions that have been identified during pre-feasibility study and to make recommendations on the most appropriate intervention combination for scaling. The evaluation included the assessment of associated emission reductions, calculating the expected improvement in air quality, and gauging the acceptability of the interventions to households.

The pilot consisted of discrete activities. Each activity yielded learnings. A selection of learnings per activity is reflected here:

- **Learnings relating to performance of the interventions**

In short, LPG stove and heater with a retrofit effectively eliminate coal use. Full retrofits performed better than basic retrofits in the pilot study, but there is still uncertainty because of the small sample and high variability of measurements. Low emission stoves may be an option in areas where solid fuels are free, especially if they are as effective in real life as in the laboratory test. Electricity subsidies did not work.

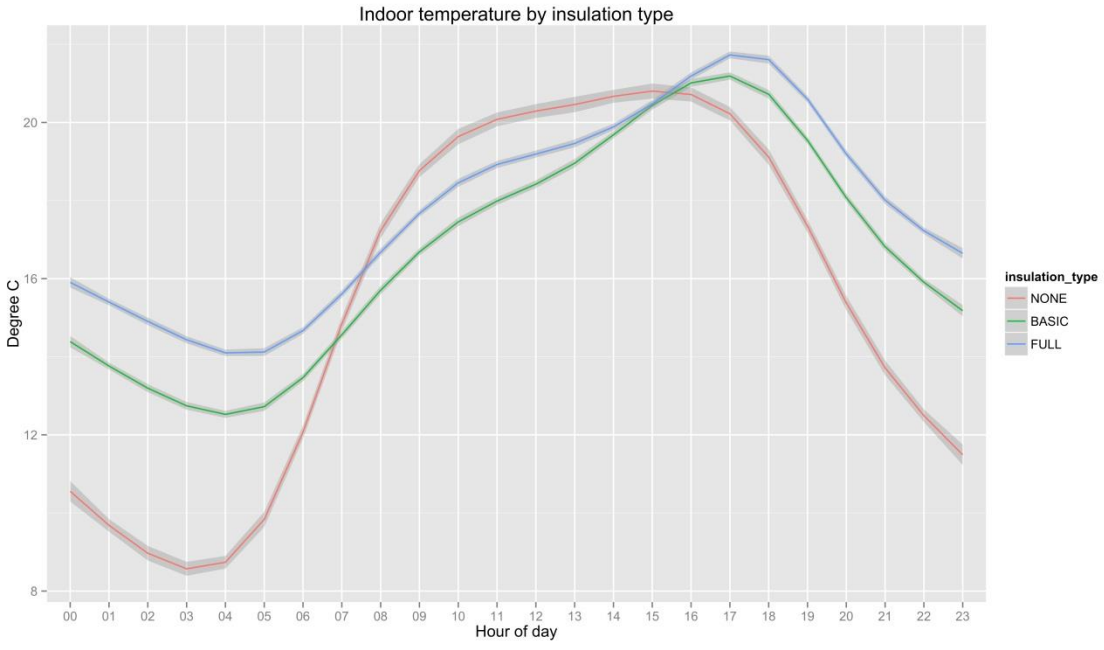

Figure A3: Winter indoor temperatures raised by insulation type

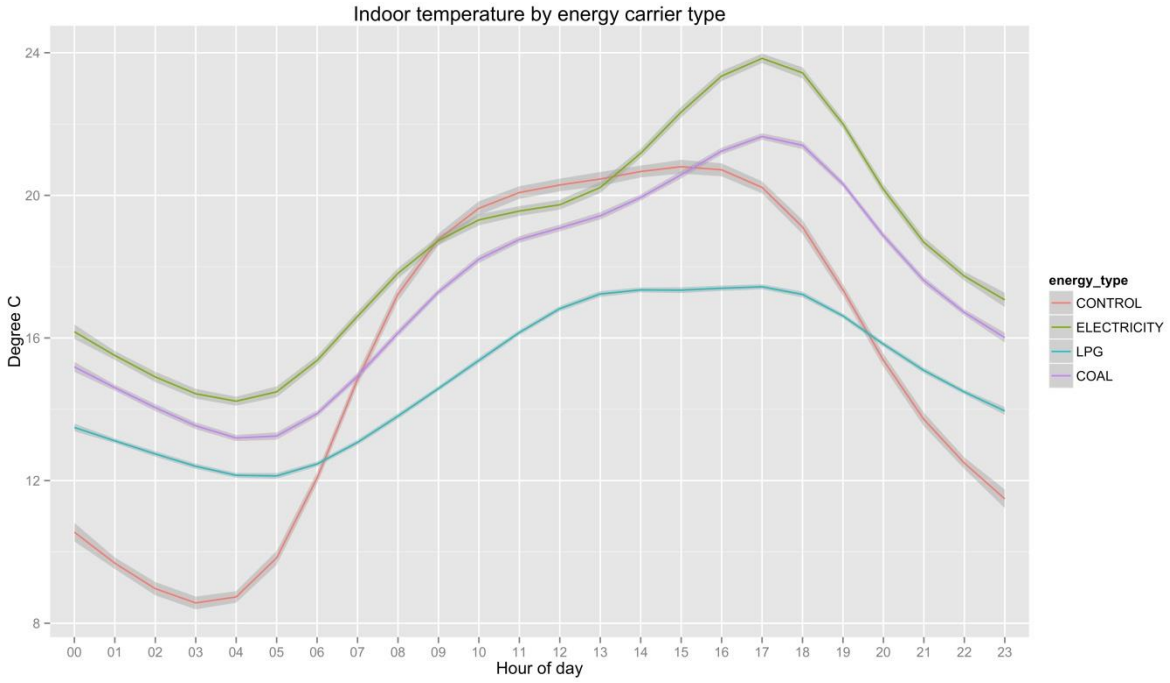

Figure A4: Winter indoor temperatures raised by energy carrier type

As participation is voluntary, it is important that any intervention is well communicated in order for households to make an informed decision whether to participate. Well over 80% of households agreed to participate in the LPG intervention set with full retrofit, as well as in the low emission coal stove plus full retrofit option. The basic retrofit plus LPG stove and heater combination had only a 66% participation rate.

Table A1: Participation rate of coal using households

Intervention	Approached	Qualifying	Participation rate
Ceiling + coal stove	35	29	66%
Full retrofit + coal stove	33	26	88%
Ceiling + LPG	32	24	83%
Full retrofit + LPG	24	23	87%

Generally, households did not want to switch back to their old coal stoves after one winter of use. Households were given an option to swop back to their old polluting stoves, or keep their new LPG or low emission stoves. More than 90%decided to rather keep using the new cleaner technology.

Table A2: Permanent uptake: stove swopping at end of winter:

Intervention	Accept and retain intervention device	Reject intervention device	Permanent device swop
Ceiling + coal stove	39	1	98%
Full retrofit + coal stove	38	2	95%
Ceiling + LPG	40	0	100%
Full retrofit + LPG	39	1	98%

Household surveys were conducted broadly in KwaZamokuhle, in order to understand socio-economic conditions generally (and not just in intervention participating households).

Poverty is a critical driver for ambient and indoor air pollution in KwaZamokuhle. The surveys confirm that KwaZamokuhle is home to many low income households, with most people living below the food poverty line. In the face of energy poverty, low-income households use dirty energy carriers in order to fulfil their need for space heating.

- **Learnings from pilot rollout planning and implementation**

A lot of interaction and consultation with the local community is essential. The interaction should take the form of both a structured local forum and an ongoing local presence that can deal with individual concerns and requests as they arise.

Recruitment and training of local labour was successful.

Figure A5: Member of the newly appointed team being trained on the installation of insulation at the storage facility near KwaZamokuhle.

Pre-existing roof leaks is a challenge and insulated ceilings decrease the amount of moisture than can escape from the roof cavity.

Figure A6: Brown marks on the ceiling as a result of roof leaks.

- **Learnings from air quality monitoring**

KwaZamokuhle often has little wind, implying that smoke from coal stoves remain trapped in community air space below the inversion layer, especially during winter. This exacerbates the health risk from household coal use to the local community.

Figure A7: Eskom monitoring site in KwaZamokuhle

Air quality in KwaZamokuhle is poor and the poor air quality is associated with household coal burning – morning and evening concentration peaks are associated with domestic cooking and space heating with solid fuels. Both ambient PM10 and PM2.5 concentrations are high, and PM2.5 (which has a more negative health impact) make up a significant part of the concentration. From end May to middle of August (the cold season), the air quality is worse. Ambient standards are exceeded on most winter days, as well as to a lesser degree during warmer months. Ambient SO_2 and O_3 concentrations are high, but in compliance of the ambient standards during the monitoring campaign. Ambient NO_2 concentrations did not exceed ambient standards.

Table A3: Ambient air quality in KwaZamokuhle between 1 January 2015 and 24 October 2016 compared to South African air quality standards.

Agent	Period	Standard	Exceeds	Average	Confidence Interval	N	N exceeds	Std Dev	Median	25%	75%	99%
PM10 (ug/m3)	24h	75	4	75	71-80	309	132	40	64	44	103	178
PM10 (ug/m3)	Annual	40	0	75		1	1					
PM2.5 (ug/m3)	24h	40	4	40	37-42	278	114	22	33	24	53	99
PM2.5 (ug/m3)	Annual	20	0	40		1	1					
SO2 (ppb)	10min	191	526	27	27-27	15244	29	23	19	14	31	129
SO2 (ppb)	1h	134	88	25	24-26	2665	15	21	19	13	30	107
SO2 (ppb)	24h	48	4	20	18-22	91	0	9	19	12	25	44
SO2 (ppb)	Annual	19	0	20		1	0					
NO2 (ppb)	1h	106	88	17	17-18	2706	1	10	15	11	21	53
NO2 (ppb)	Annual	21	0	17		1	0					
O3 (ppb)	8h	61	11	25	25-25	7521	3	10	24	18	31	51

Household emissions were a more significant source of SO_2 than regional sources with peak concentrations occurring in the evening. Households accounted for about 75% of the peak concentration. Regional industry contributed about 25% of the peak concentrations.

There is no observed morning peak of SO_2 to match the morning peak in PM10. This may be due to reactions that occur in the morning that effectively convert SO_2.

Source apportionment results for the winter samples indicate that domestic cal combustion is an important source in both the coarse (38.7 %) and fine fraction (63.4 %). Dust sources are also important in the coarse fraction (42.5 %). In the fine fraction emissions from automobiles and secondary sulphate and nitrate contributed 13 % and 8.5 % of the aerosol loading respectively.

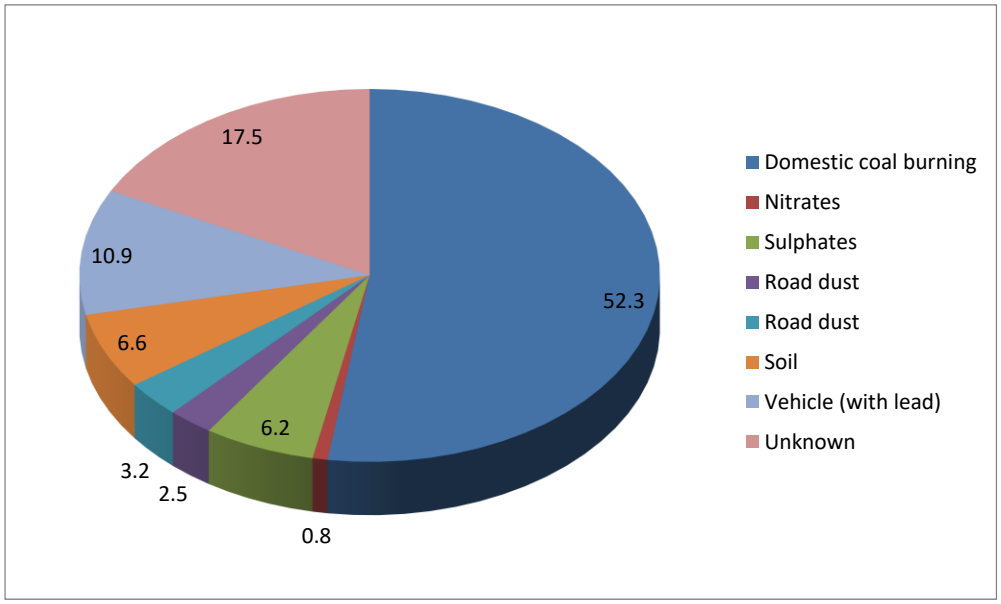

Figure A7: Source apportionment of the fine particulate matter (PM2.5) in KwaZamokuhle in winter 2015

- **Learnings from dispersion modelling**

The emissions inventory in its current form is adequate for modelling potential changes in ambient concentration due to interventions if rolled out at scale.

The inclusion of observed meteorological data significantly improved model performance for PM10 evening peaks by assimilating calm conditions.

- **Learnings from macroeconomic impact assessment and social cost benefit analysis**

Indicative results are that health impacts and costs relating to local air pollution will be greatly reduced due to the reduction in coal consumption through the interventions' efficiency improvements and fuel substitutions. The interventions will make a positive contribution to job creation and GDP. The interventions will reduce greenhouse gas emissions.

The results show that the basic retrofit and LPG intervention has the highest benefits to cost ratio. The benefits of some interventions were less than the costs over a 20 year timeframe, however the assessment excludes the value of continued licensed operation by power stations. Furthermore, we can expect all interventions to improve as more information of intervention performance becomes available.

It should be noted that from a pilot study of this size, no conclusive macro environment findings can be expected – therefore results are indicative.

➢ **Learnings from offset methodology development**

An overarching framework for accounting for the impact of air pollution has been developed. This Air Pollution Impacts Protocol was successfully used to develop two methodologies and four supporting calculation tools. The methodologies have been tested and are practically applicable.

Figure A8: Images of the installation process, completed thermal installations and stove replacements

12.2 AIR QUALITY OFFSETS: 30-HOUSE ELECTRICITY PILOT STUDY

At the conclusion of the 120-House pilot, the project team was requested by Eskom management to pilot test the feasibility providing household with electrical devices - stove and heater (rather than previous approach which involve provision of an LPG stove and heater). The pilot study was conducted on 30 households during 2017. The main objective of the pilot study was to understand willingness of coal-using households to swap their coal stove for an electric stove, electric heater, energy efficient lighting and a full retrofit (wall and ceiling insulation plus draft proofing).

The results of the pilot study indicated that it was feasible to switch households from coal to electricity, however there were several risks raised, which would limit the success of an electricity-based intervention. To address the risks identified with the electricity based solution, recommended mitigation measures are detailed in the table below:

Table A4: Risks and mitigation measures for the electricity based intervention

Risk	Possible mitigation measures
Electricity interruptions due to faults or outages	This risk will be mitigated by the fact that an LPG backup will be provided. The project team will work with Eskom Distribution and the affected Local Municipality to strengthen supply in the area and limit interruptions.
Social unrest resulting from Eskom debt collection through municipality electricity cut-offs	Eskom customer services stakeholder engagement is assumed to address this issue. LPG back up also mitigates this risk.
Electricity price increases	Insulation of the houses will result in a lower or equal energy cost relative to the post-intervention situation. Electricity and Gas prices are likely to increase the extent of which is dependent on many factors e.g. health the economy and demand for the commodity.

12.3 RECOMMENDED HOUSEHOLD INTERVENSION FOR THE LEAD IMPLEMENTATION

Based on the results of the studies conducted to date it was concluded that ambient air quality in the affected communities could be improved by replacing household's coal stoves with a hybrid gas electricity stoves and a LPG heater together with retrofitting the houses with a ceiling to insulate the houses.

The recommended Air Quality Offset intervention for the lead implementation entails the following (Figure (9A);

- Provision of a basic plus retrofit which consists of;
    - Insulation entailing installation of a SPF ceiling system and draft proofing
    - Electrical rewiring and issuance of Certificate of Competence (CoC).
- Stove swap which entails

- Provision of electricity based energy source with LPG backup. This will include a hybrid electric gas stove, LPG heater plus 2x9 kg LPG cylinders and Compact fluorescent lamp (CFL) for energy efficiency lighting.
- Removal and disposal of the coal stove

Figure A9: Household Intervention for Lead Implementation Sites (KwaZamokuhle and Ezamokuhle)

Electricity is the cleanest source of domestic energy. Rather than providing an LPG stove, heater and cylinder in exchange for the household's coal stove, Eskom is now proposing to provide a hybrid gas electric stove and LPG heater. The proposed changes have impacted the planned schedule for the rollout of the interventions especially in Nkangala and Gert Sibande.

13. APPENDIX B: SUMMARY OF EXPENDITURES FOR ESKOM'S AIR QUALITY OFFSETS PROGRAMME

Area / Township	Year	Quarter	Activity / Action	Status	Cost / budget
KwaZamokuhle	2016	Q1	Offset pilot KwaZamokuhle (150 households)	Ongoing	
KwaZamokuhle		Q2	Offset pilot KwaZamokuhle (150 households)	Ongoing	
KwaZamokuhle		Q3	Offset pilot KwaZamokuhle (150 households)	Ongoing	
KwaZamokuhle		Q4 – Total expenditure 2016	Offset pilot KwaZamokuhle (150 households)	Ongoing	R 6957 000
KwaZamokuhle & Sharpeville	2017	Q1	Offset pilot KwaZamokuhle (150 households) Sharpeville baseline study	Ongoing	
KwaZamokuhle		Q2	Offset pilot KwaZamokuhle (150 households) Sharpeville baseline study	Ongoing	
Sharpeville		Q3	Offset pilot KwaZamokuhle (150 households) Sharpeville baseline study	Ongoing	
KwaZamokuhle		Q4 – Total expenditure 2017	Offset pilot KwaZamokuhle (150 households) Awareness & communication	Ongoing	R 11 477 509
KwaZamokuhle & Sharpeville	2018	Q1	Offset pilot KwaZamokuhle (150 households) Awareness & communication	Ongoing	
KwaZamokuhle & Sharpeville		Q2	Offset pilot KwaZamokuhle (150 households)	Ongoing	
KwaZamokuhle & Sharpeville		Q3	Offset pilot KwaZamokuhle (150 households) Awareness & communication	Complete	
KwaZamokuhle & Sharpeville		Q4 – Total expenditure 2018	Offset pilot KwaZamokuhle (150 households) Proactive assurance Promotional material	Complete	R 3 119 535
KwaZamokuhle, Ezamokuhle, Sharpeville	2019	Q1	Internal costs – Project planning	Complete	

KwaZamokuhle, Ezamokuhle, Sharpeville		Q2	Vaal Environmental Celebration Day	Complete	R 59 255
KwaZamokuhle, Ezamokuhle, Sharpeville & Emzimnoni		Q3	Health Study done by South African Medical Research Council	Ongoing	R 1 092 640
KwaZamokuhle, Ezamokuhle, Sharpeville & Emzimnoni		Q4	Vaal environmental day, Health study by SAMRC and media training	Complete	R 1 797 359
KwaZamokuhle, Ezamokuhle, Sharpeville	2020	Q1	Stakeholder communication material	Ongoing	R 6 419
KwaZamokuhle, Ezamokuhle, Sharpeville		Q2	Stakeholder communication material	Ongoing	R 244 410
KwaZamokuhle, Ezamokuhle, Sharpeville		Q3	Stakeholder communication material	Ongoing	R 108 109.00
Total (to date, since 2016)					**R 24 861 606**